U. S. Department of Agriculture - Forest Service
CENTRAL STATES FOREST EXPERIMENT STATION
Columbus, Ohio

FOREST SERVICE
JUN 20 1935

INTERMOUNTAIN STATION
Central Reference File
No. 0.73

Station Note
No. 24

June 1, 1935.

THE EFFECT OF WOODLAND GRAZING ON CERTAIN SITE FACTORS IN THE OAK-HICKORY TYPE

By Oliver D. Diller, Technician

The almost universal practice of woods grazing in the better agricultural sections of the Central States is quite generally recognized as the major cause of the continued deterioration of the farmwoods in these sections. In certain limited areas they are faced with almost total extinction if present grazing practices are continued. Fully fifty per cent of the farmwoods in the Corn Belt are no longer capable of yielding valuable forest products, nor are they of any great value for the production of forage. Although this situation is acute, as yet there has been insufficient research on the basic economic and silvicultural relationships of grazing to the farmwoods. Such a comprehensive study has been started on a cooperative basis between the Central States Forest Experiment Station and the Purdue Agricultural Experiment Station.

Periodic remeasurements of permanent sample plots established in connection with this study have demonstrated that natural reproduction cannot be secured without complete protection from grazing. Plots located in woodlands from which livestock have been removed for periods of from one to twenty-five years indicate that where such areas have not passed beyond a certain stage of decadence they are capable of natural recovery to a productive forest condition. Other woodlands which have deteriorated to the point where a complete sod cover had become established were found to be incapable of natural recovery within a reasonable length of time.

The data available from a study of permanent sample plots were insufficient to establish the causal relationships involved. A more intensive ecological study was made by the writer* during the summers of 1932 and 1933 to determine the effect of excessive grazing on certain environmental or site factors, and to ascertain under what conditions they become limiting in the germination, survival, and establishment of natural tree reproduction. These intensive site studies were carried on in quadrats, 2-mil-acres in area, which were located in a number of northern Indiana farmwoods representing the various stages of grazing. Observations and periodic measurements made in these quadrats served to establish some significant relationships, which are herein briefly summarized. Since woodland grazing is the most severe in the better agricultural areas of the Corn Belt, it was assumed that mineral elements of the soil did not constitute limiting factors, and, therefore, no studies of this nature were undertaken. It is hoped that this project may be continued through several more seasons because these data were collected during a severe drought period, which may have influenced the results obtained.

---

* This investigation was made possible by cooperation between the Department of Botany, Ohio State University; the Central States Forest Experiment Station; and the Department of Forestry, Purdue Agricultural Experiment Station.

INT-FILE COPY

Soil Moisture. Periodic moisture determinations were made in quadrats representative of varying degrees of decadence and subsequent recovery from previous grazing. These studies indicate that soil moisture is one of the most important limiting factors in establishment of natural reproduction. Red oak seedlings, for example, did not survive a moisture content of 4.7%, or 22.7% of the moisture equivalent. In the more advanced stages of decadence, where the stands have been opened up to the extent that the soil is subjected to excessive evaporation, the moisture content in the upper 10 inches of soil reached or fell below this critical point early in the growing season. A low of 3.8% moisture content, or 17.9% of the moisture equivalent, was recorded on July 25, 1933.

This soil moisture relationship explains, in part at least, one of the most perplexing problems in the natural regeneration of grazed farm woodlands. It has been frequently observed that many woodlands contain an apparently promising stand of reproduction during the late spring and early summer months, but by mid-summer the seedlings almost entirely disappeared. Repeated observations on the same area have indicated that this may happen year after year, with no material survival from one year to the next. It seems probable that the woodlands which have been partially opened up through continuous grazing, and have a complete sod cover established, suffer greater loss of soil moisture than in any other stage of decadence. This will be discussed at greater length in the last paragraph of this paper.

Soil Porosity and Water Absorption. Continued overgrazing has a deteriorating effect on the physical condition of the soil. It produces a hard, compacted, and poorly aerated surface horizon, incapable of high moisture absorption, and, in general, of such low tilth as to provide very unfavorable conditions for germination and establishment of tree seedlings. Auten (1) found that the weight of samples from the upper nine inches of soil in grazed woods averaged 15 per cent heavier than corresponding soil sections in ungrazed woods. Similar studies made by the writer in previously grazed woodlands from which the cattle had been removed for varying periods, indicate that with protection these soil conditions gradually become more favorable for regeneration. The average weight of soil samples taken from the upper 3 inch layer of soil in woods protected from grazing for more than ten years was 15 per cent lighter than similar samples taken from woods from which cattle had been only recently removed. A series of water absorption tests further demonstrated this gradual improvement of environmental conditions. It was found that after 16 years of protection the surface soil absorbed water more than 7½ times as rapidly as the surface soil of woodlands which were being grazed at the time the tests were made.

Leaf Litter. Too much emphasis cannot be placed on the importance of a leaf litter cover in producing an environment most suitable for the germination and survival of the heavier seeded tree species. The outstanding influence of leaf litter is to conserve moisture, to act as an insulator against climatic extremes, to return certain mineral elements to the soil, and to retain soil porosity. Grazing inhibits the accumulation of leaf litter through trampling the litter into the mineral soil where decomposition takes place very rapidly. Disintegration of litter is also hastened

---

(1) Auten, John T. - Porosity and Water Absorption of Forest Soils. Journal Agr. Res. Vol. 46, No. 11, Washington, D. C. June, 1933. Summarized as Station Note No. 8.

by the increased desiccating action of both wind and sun which accompanies the opening up of the stand. This increased wind action also results in erratic distribution of leaf litter. In the more open woods the litter accumulates against the leeward fence or is blown entirely out of the woods.

The Influence of Light. Under favorable forest conditions, foresters consider light as one of the most important factors necessary in successful natural regeneration, and, therefore, it is seldom regarded as inhibiting in its effects. In the open farmwoods of the Corn Belt, however, where prairie conditions are approached, it appears that too much light reaching the ground may have certain harmful effects, especially on very young seedlings. It appears that this unfavorable effect of direct sunlight becomes important through its interrelated effects on soil temperature, relative humidity, evaporation, transpiration, soil moisture, and the formation of a sod cover.

Hourly fluctuations in radiation were found to be of as great importance as the total radiation throughout the day. The light intensity determinations indicate that optimum conditions are found for survival of red oak seedlings where the intensity at the ground does not exceed 46 per cent of the intensity in the open at any time of the day. Light intensity measurements taken on quadrats where the seedlings were in an unhealthy condition were found to average over 50 per cent of the intensity in the open during the noon hours, and reached a maximum of 65 per cent. Quadrats where most of the reproduction had died were exposed to full sunlight during the greater part of the day.

These data support the earlier conclusions of Day and DenUyl (2) that the density of the overhead stand is one of the two principal factors controlling the germination, establishment, survival, and growth of reproduction in the grazed farmwoods. It is evident that as the crown canopy becomes more open a greater amount of solar radiation reaches the ground, which adversely influences the environmental conditions by raising the soil and air temperatures, lowering the relative humidity and soil moisture, and increasing evaporation and transpiration.

Temperature. The average maximum soil temperature at a depth of two inches was found to be higher on those quadrats where most of the seedlings had died, and also on those quadrats where they were unhealthy, than on quadrats where the reproduction was in a healthy condition. The respective readings were 82.7°, 74.4°, and 71.0°F. Whether these figures are significant remains to be determined. While it seems improbable that these relatively low temperatures are limiting in themselves, it is evident that sub-surface soil temperature does have an important effect on the rate of evaporation of moisture from the soil. The study of soil temperatures has also further demonstrated the value of even a slight cover of leaf litter in equalizing soil temperatures and lowering the maximum, thereby preventing excessive evaporation. Further study is needed of the effect of high surface temperatures which may become limiting on certain exposed south slopes.

---

(2) Day, R. K., and DenUyl, D. - The Natural Regeneration of Farm Woods Following the Exclusion of Livestock. Purdue Univ. Agr. Exp. Sta. Bull. No. 368, 1932.

Wind Velocity. In grazed woodlands which have passed into or beyond the "transition" stage of decadence, wind movement and air currents are much more noticeable than in ungraced or lightly grazed areas. This adversely affects a number of interrelated environmental factors, particularly soil moisture and temperature, relative humidity, and air temperature. Even slight air movement removes the blanket of more or less saturated air surrounding the leaves, increasing the diffusion gradient and thus accelerating the rate of transpiration until wilting occurs. Any increase in transpiration rate is injurious when the soil water is at the critical point.

The Cumulative Effect of Increased Transpiration and Evaporation. It has been previously stated that woodlands in which a complete sod cover has been established through a partial opening up of the stand probably suffer a greater loss of soil moisture than any other stage in the transition from dense forest to open pasture. In these woods the factors which tend to conserve moisture have been materially disturbed through the compacting of the soil surface, the disappearance of the protective leaf litter and mull, the elimination of the shrubby undergrowth and tree seedlings which served as an effective barrier against free wind movements, and through the formation of a sod cover. On the other hand, the tremendous amount of transpiration which takes place in the dense forest has been only moderately reduced through the reduction in the number of trees. It seems probable that the considerable increase in evaporation directly from the soil under conditions which approach those of an open prairie is not materially offset by this decrease in transpiration from the overhead stand. This opinion was verified indirectly in a series of trenched and untrenched plots in which an attempt was made to evaluate the influences of crown canopy and sod cover separately. This was found to be impossible, due to the fact that the increase in soil moisture content, which was anticipated through the reduction of tree root competition, was offset by the increased growth and transpiration of blue-grass on the trenched plots.

To summarize this progress report, soil moisture appears to be the principal limiting factor in the satisfactory regeneration and rehabilitation of those grazed woodlands which have reached the advanced stages of decadence. The other factors apparently become limiting chiefly through their interrelated effect on the moisture factor.